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The F/A-18E/F: An Integrated Product Team (IPT) Case Study

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1.0 Introduction

The Navy's newest fighter and attack aircraft is the F/A-18E/F. The F/A-18E/F represents an evolution from the previous F/A-18 models (the A/B and the C/D). While its aerodynamic architecture is similar to that of the other models, it is 25% larger, carries a heavier payload, and has longer range. At the same time, it has one-third fewer parts. The aircraft is currently undergoing developmental test and evaluation at the Naval Air Station in Patuxent River, Maryland. The success achieved to date by the F/A-18 program is well summarized by this quote from White[1] of Johns Hopkins Applied Physics Laboratory:

> By almost any measure, the F/A-18 is a successful military acquisition program. The combat-tested F/A-18 aircraft are among the world's best. The upgraded E/F version [is in the third and final year of its] engineering and manufacturing development phase of its acquisition cycle. The first flight was 1 month early with no cost overruns, and the aircraft weight was 1000 lb below the specification. The aircraft's technology is complex and challenging, but just as challenging is managing the thousands of people and the hundreds of organizations that contribute to its success.

The F/A-18 program office is organized around Integrated Product Teams (IPTs). This case study traces the evolution of the F/A-18 program from a functionally aligned organization to the current structure of product-oriented interdisciplinary teams. The case study was sponsored by the Office of the Under Secretary of Defense (Acquisition and Technology) to provide a real-life example of IPTs and Integrated Product and Process Development (IPPD) from an acquisition perspective. The transition to IPTs began with a high-level vision and required a great deal of thought, effort, and persistence to turn that vision into a concrete reality. That this was not a simple undertaking is attested to by the fact that it has been the topic for one doctoral dissertation.[2]

Material for this case study came from a series of interviews that took place at the F/A-18 Program Office in Patuxent River, Maryland, during the Fall of 1997.

[1] White, James W. "Application of New Management Concepts to the Development of F/A-18 Aircraft," *Johns Hopkins* APL *Technical Digest*, Volume 18, Number 1, pp. 21–32, 1997.

[2] Snoderly, John Ross. *The Application of Integrated Product Teams Concepts to the Organizational Structure of the Federal Government: A Study of F/A-18E/F and V-22 Implementation*, School of Public Administration, University of Southern California, Doctoral Dissertation, December 1996.

Much of the historical perspective emerged from interviews with Rear Admiral Joe Dyer,[3] Captain Gib Godwin, and Jim Keen, all of whom were involved in the transition process from the earliest days. Additional perspectives were derived from interviews with IPT leaders and members at multiple levels. All of these people took an active interest in the case study and gave generously of their time in order to share their experience and lessons learned with others in the Department of Defense acquisition community.

[3] In several cases, quotations are taken from an audiotape of a 1996 presentation given by RADM Dyer. (Joseph Dyer and Clayton Conger, The Evolving Integrated Program Team Project Management Institute, 1996 Annual Seminars and Symposium, Boston, Massachusetts.)

2.0 Scope and Outline of the Case Study

This case study focuses on the use of IPTs within the government acquisition office. It does not cover the use of IPTs on the contractor side; a parallel case study could be written from that perspective as well.

The case study traces the history of one organization as it made the transition away from strong functional alignments to a product orientation. It makes no attempt to serve as a tutorial on IPTs. It assumes that the reader has a basic knowledge of IPTs and of IPPD. No attempt is made to draw cause and effect conclusions by claiming that the success of the F/A-18E/F acquisition is due to IPTs (although the people interviewed felt that IPTs were a key part of that success). Rather, the objective is to describe important events and lessons learned in the words of those who participated.

In Section 3.0, the case study begins with a discussion of the historical background motivating the transition to IPTs within the Navy's Naval Air Systems Command (NAVAIR). The F/A-18 program was chosen to be the prototype for this transition. Once the decision was made to move away from a functional to a product orientation, many details had to be worked out. The case study describes a series of key meetings during which these details became more concrete. The transition to IPTs evolved over time and met with a great deal of initial resistance. According to Admiral Dyer, who was the Program Manager during this period, the single most important characteristic of the key players in those early days was the courage to stand up to this resistance.

Section 4.0 describes the structure of the IPTs. Section 5.0 highlights key concepts or themes that emerged from the interviews. Section 6.0 discusses an example of IPTs in action. It traces the events following the failure of an engine during test flight and describes the teamwork involved in diagnosing and implementing a solution. The entire cycle from the time the problem appeared until the cause was identified and a solution was implemented was an amazingly short six weeks. Section 7.0 summarizes lessons learned by the F/A-18 Program Office in implementing IPTs. Section 8.0 lists the individuals who were interviewed. Section 9 contains the list of acronyms.

3.0 Historical Background

The F/A-18E/F program is part of NAVAIR, currently headquartered in Patuxent River, Maryland. The program office (PMA265) has total life-cycle responsibility for three different models of the F/A-18. The A/B model was first fielded in 1984 and is currently out of production. There are 325 A/B aircraft in active service. The C/D model was fielded in 1988 and has recently completed the end of its production run. There are approximately 500 C/D aircraft in active service. In 1992, McDonnell–Douglas was awarded the contract for full-scale development of the E/F model. Currently, seven test aircraft are undergoing developmental test and evaluation at the Patuxent Naval Air Station. The E/F model is scheduled to be fielded in 2002. The E/F is larger and heavier than its predecessors. The avionics are 90% common with the C/D. Thus, it represents an evolutionary design from the C/D.[4]

In terms of manpower, the F/A-18 Program Office manages approximately 2,000 full-time equivalent staff years, geographically distributed between NAVAIR headquarters in Patuxent River, Maryland, and several field activities and depots.[5] In terms of dollars, it is about a $4-billion-a-year program, distributed between the operational support of existing aircraft (including foreign military sales), and engineering and manufacturing development of the E/F model.[6]

The seeds for change within NAVAIR emerged from the well-publicized failure of the Navy's A-12 aircraft which was cancelled in 1991.[7] At that time, NAVAIR was organized around strong functional stovepipes, each reporting within its own chain of command. In the words of Admiral Dyer,

> We had strong functional management and weak program management. People reported up their own functional chain of command. The Program Manager subcontracted work to each of the functional organizations and was left herding cats.

Disagreements between functional organizations were raised up the functional chain to be resolved at the top level rather than at the level at which they surfaced.

[4] This information was obtained by the author during March, 1996 during an interview with Darrell Maxwell and Charles Bechtel of the F/A-18 Program in China Lake, California, as part of a separate study undertaken by the Logistics Management Institute for the Office of the Assistant Secretary of Defense, Logistics.

[5] John Snoderly's dissertation referenced above, pg. 123.

[6] Interview with CAPT Godwin, October 14, 1997.

[7] "Death of the A-12. No more blank checks, insists Defense Secretary Cheney as he shoots down a $57 billion Navy attack bomber, *Time*, January 21, 1991.

Not only was the program management relatively weak but, under this organization, work proceeded in a serial fashion across functional organizations, leading to a great deal of rework. For example, the development of a Request for Proposal (RFP) would begin with an operational concept produced by one organization (Office of the Chief of Naval Operations (OPNAV)). It would then move to engineering for a more detailed delineation of requirements. It would then move to the logistics organization. From there it might go to contracting, finance, and then the legal department. In the words of Admiral Dyer,

> As the activity moved from one functional area to the next, it would be clear that a decision made earlier could not be implemented by the next area. So things were sent back, rework had to be done. This was expensive and caused delay.

Not only was this inefficient, with a lot of rework, but the appropriate tradeoffs among functional disciplines were not being made. Admiral Dyer describes this as "setting out to design a race horse and ending up with a camel. Every organization tried to optimize from their perspective. The tradeoffs were not there."

In 1992, the Commander of NAVAIR, Vice Admiral Bowes, commissioned a team of nine people to develop a new Concept of Operations for acquisition management within NAVAIR. This team recommended that NAVAIR move away from functional stovepipes to a product orientation in which all functional areas worked together as a team concurrently, the IPT concept. This recommendation followed a series of briefings from industrial organizations that had made this transition successfully. These included Hughes, General Electric, Chrysler, Ford, Boeing, and McDonnell–Douglas.

A high-level plan was developed to transition to IPTs. It is noteworthy that this preceded the Secretary of Defense memorandum (dated May 10, 1995) directing the use of IPTs throughout the Department[8] within three years. The F/A-18 program was selected to be a prototype for implementing IPTs. In 1994, (then) Captain Joe Dyer, who had been part of the team that wrote the Concept of Operations, was selected as Program Manager.

One of the early decisions outlined in the Concept of Operations was to matrix the functional organizations across the IPTs. The functional areas were referred to as Competency Aligned Organizations (CAO) and included:

- Program Management,
- Contracting,
- Logistics,
- Research and Engineering,

8 Secretary of Defense memorandum, Use of Integrated Product and Process Development and Integrated Product Teams in DoD Acquisition, May 10, 1995.

- Test and Evaluation,
- Industrial Capability,
- Corporate Operations, and
- Shore Station Management.

Rather than serving as stovepipes in a sequentially organized workflow, the functional areas would now serve as resources of expertise in staffing IPTs. From this high-level vision, there remained many details to work out.

Dyer's first step in breaking down the functional boundaries was to move the systems engineers from a building next door to the Program Office into the space occupied by the Program Office so that they were collocated. When looking back to this period, Dyer pointed to the importance of collocation.

> The Flag Officers [who were in command of the functional organizations] fought collocation. The Flag Officer for engineering protested by saying 'You're going to dilute our engineering resources. You'll have our engineers worrying about contracting and finance.' To which I responded 'You're darn right.' The Flag Officer for logistics wanted all the logisticians together. So I let them stay together and I surrounded them with my team.

During 1994 and 1995, a series of meetings was held to define the IPT structure for the F/A-18 program and to develop the detailed procedures for how the IPTs would work in practice. The Deputy Program Manager at that time was Captain Godwin. He is now the Program Manager. In Godwin's words:

> There were two meetings that I can only describe as watershed events. The first was in Albuquerque in September 1994. This was a one-and-a-half-day meeting during which we defined the IPT structure. We had about 20 people there — the whole leadership team consisting of the top-level (Level 1) IPT leaders plus competency specialists (e.g., engineering, contracting). Then there was a second meeting at Key West in February 1995 that lasted for two days. We brought in people from different functional areas that were not with the F/A-18 program so that they would be objective. We defined in some detail how the IPT/Competency Based Organization would work. There were a lot of issues that had to be addressed, such as who would do performance reviews, who signs timecards, and so on.

At this point, there was a lot of resistance. In Godwin's words,

> People said it's too hard to do. It represented a big redistribution of power within the organization away from engineering to more of a balance across functional areas. Engineering had the dollars before. Now the dollars are distributed pretty evenly among the three Level 1 IPTs [described in

> Section 4.0]. I don't want to give anyone the impression that this was easy. It was difficult, frustrating, and gut wrenching.

In looking back to this earlier period, Captain Godwin pointed out that a few key people were energized and worked very hard to bring the transition about. This included key people within the functional organizations as well as the early top-level IPT leaders.

During 1995, a team of six people was tasked to write a Program Operating Guide (POG) documenting the IPT structure and the details of how the IPTs would operate on a day-to-day basis. The first edition of the POG came out in mid-1995.[9]

9 *F/A-18 Program Team (PMA265) Program Operating Guide,* Program Executive Officer for Tactical Aircraft Programs (PEO(T)), June 1995.

4.0 IPT Structure

The IPTs, as they are implemented within the F/A-18 program, are *integrated*, in that all of the functional disciplines involved during the product's life cycle are brought together from the beginning so that decisions are made concurrently rather than in the old serial fashion.

These are *product* teams, with a strong emphasis on product. The POG makes this point very clearly:

> These teams are formed around products, not functions. First we offer *a simple test for a product – 'Is it something the Fleet asks for?'* The Fleet and our foreign customers demand, for example, radar, landing gear, and weapons. They never send messages saying, 'Send us some test and evaluation,' or 'send us some logistics.' Consequently...we have a radar team; we do not, and shall not, have a logistics or a T&E team.

In a 1996 symposium,[10] Admiral Dyer made the following observation:

> When we first started putting together IPTs, all of our functional groups wanted their own IPT – the Test and Evaluation people wanted a Test and Evaluation IPT, the logisticians wanted a Logistics IPT, the contracting officers wanted a Contracting IPT. By the time you got through, this looked just like where you came from. So we applied a test for IPTs; it had to be something the fleet asked for. The fleet never, ever called me up and said 'Get me some T&E our here in a hurry' or 'Boy, would we like to have some logistics.' We focused our IPTs on product and then asked 'What does it take to deliver the product?' These are the disciplines that have to come into every IPT.

The IPTs are *teams*. One view, expressed in several of the interviews is that one person, no matter how smart, can never make decisions as well as can a team. The E/F Level 1 IPT Co-Leader, Captain Jeff Wieringa stated,

> We say to people, 'put your E/F hat on, join the team and learn all perspectives.' I'm a facilitator and a consensus builder. Team leaders are not defending their stovepipe but working together.

The IPTs are structured hierarchically as depicted in Figure 1.[11] At the top level (Level 0) is the Program Manager, currently Captain Godwin. He is the person who is ultimately accountable for delivering a quality product within cost and schedule. This responsibility is "cradle to grave," extending over the entire life cycle of the F/A-18, not just until

[10] Presentation given by RADM Dyer (Joseph Dyer and Clayton Conger, The Evolving Integrated Program Team, Project Management Institute, 1996 Annual Seminars and Symposium, Boston, Massachusetts).

[11] *F/A-18 Program Operating Guide,* November 1996 (2nd edition), p. 3.

deployment into the field. There are three IPTs at Level 1 (represented by three pyramids in Figure 1): Foreign Military Sales (FMS), E/F, and Production and Systems Development (P&SD). P&SD is responsible for several areas including:

- Operational support for the A/B and C/D models,
- Upgrades to all deployed aircraft (e.g., integrating new weapons, navigational aids, etc.), and
- Subsystems that are common to both the C/D and the E/F models (e.g., avionics).

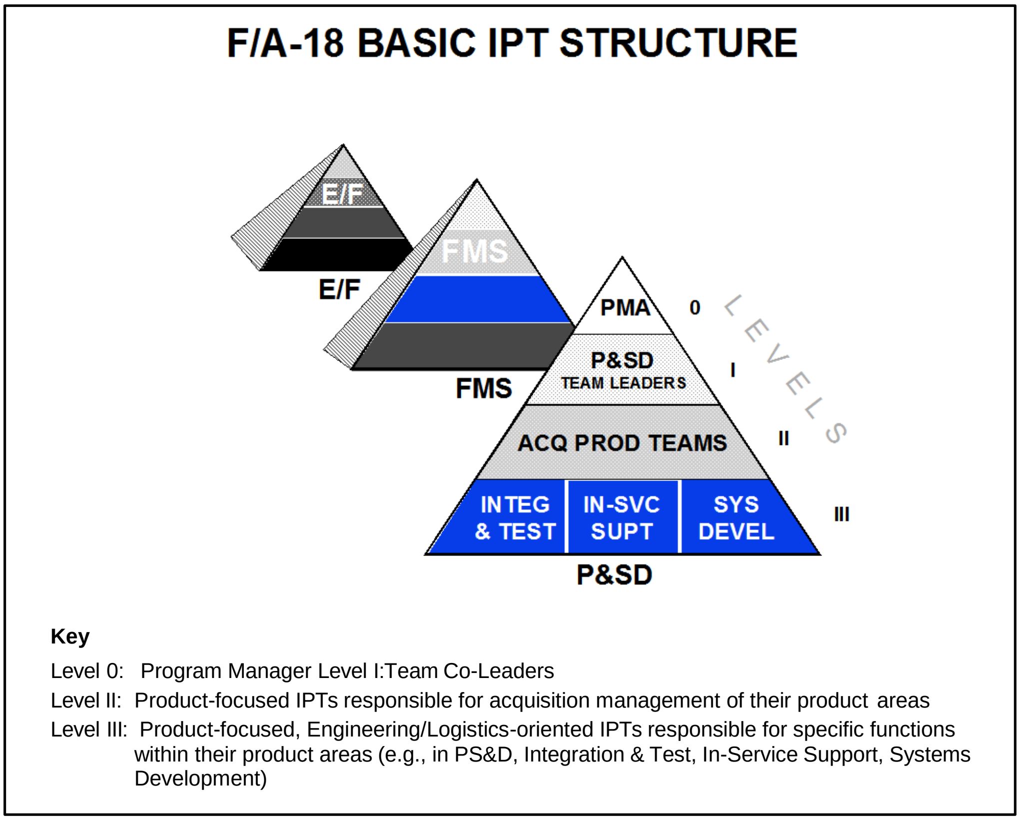

Figure 1. Hierarchical Structure of the Three Level-1 IPTs

Each Level I "team" has two IPT Co-Leaders – one an active duty military officer and the other a civilian – in order to bring together experience from the Fleet (the military member) combined with acquisition experience (the civilian member).

Level II is the next level down in the hierarchy. It is at this level that the "nuts and bolts" of acquisition management take place. Level II consists of product-oriented multi-disciplinary teams (shown in Figure 2)[12] responsible for the cost, schedule, performance, and supportability of their respective products. They work with the operational side of the

[12] *F/A-18 Program Operating Guide,* November 1996 (2nd edition), p. 4.

Navy to convert operational requirements to systems requirements, they develop an acquisition strategy, and they conduct reviews in support of program schedules.

The Level II IPTs for FMS are focused on individual countries, each of which has its own unique configuration of the aircraft. There are two E/F Level II IPTs: one for Air Vehicle and the other for Propulsion (i.e., engines). There are a total of nine Level II IPTs within P&SD, each focused on a subsystem of the A/B and C/D aircraft (e.g., Radar, Avionics). (The E/F shares a number of major subsystems with the C/D model. These shared subsystems are managed within the PS&D IPT.)

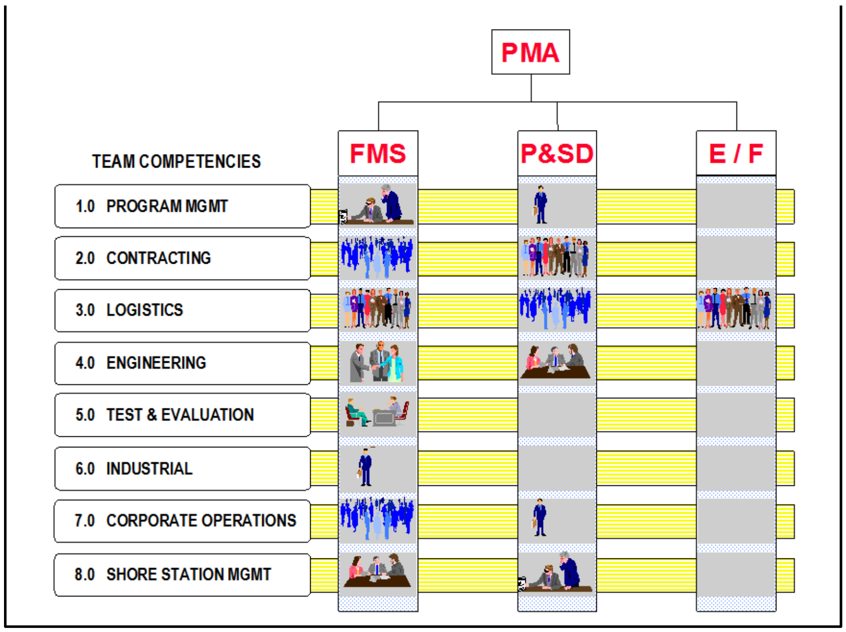

Figure 2. Product-Oriented Multi-Disciplinary Teams

At the next lower level of the hierarchy are the Level III teams. The people involved at Level III are, for the most part, engineers, and logisticians doing technical and logistics work, in contrast to the diversity of disciplines that are brought together at Level II. The Level III teams are generally located at field sites, such as China Lake and North Island, California, and Patuxent River, Maryland.

Some of the Level III teams are involved in the development of a subsystem or aircraft component and work with contractors in identifying and resolving engineering issues. For example, the E/F Propulsion and Power Level II IPT has the following Level III teams:

- F414-GE-400 Engine,
- Secondary Power,
- Electrical Power, and
- Integration (of the engines on the aircraft).

Any problems affecting acquisition management can be surfaced to the Level II team to be addressed by the variety of disciplines represented there (e.g., contracting, program management). Another Level III E/F team is the Integrated Test Team (discussed in Section 5.4) currently conducting the flight tests.

Within P&SD, teams are going down to Level IV. In general, these represent either a further decomposition of the aircraft (Leading Edge Flap), or they are formed to address a specific problem. An example of the latter is a Level IV Blinking Display Team that was formed to address a problem with the C/D model. During catapult launch off a carrier deck, there is an intermittent problem with blinking cockpit displays. Once a solution is in place, this IPT will disappear. Thus, the IPT structure is dynamic and changes throughout the product life cycle. Once the E/F model completes the engineering and manufacturing development phase of its life cycle, it may be folded into the P&SD IPT.

5.0 Key Concepts

Several of the people interviewed were asked directly "What, in your view, characterizes an effective IPT?" Five concepts emerged as key in that they were mentioned by multiple people as important or they were emphasized as being very important by one of the key players involved in the transition to the IPT structure. The key concepts are:

- High premium on information and communication;
- Team leaders are key;
- Checks and balances provided by "technical conscience;"
- Strong team culture; and
- Individuals empowered (given resources, authority, and accountability) within clearly defined roles and responsibilities.

5.1 High Premium on Information and Communication

One of the dominant themes emerging from every interview was the high value placed on open communication and on quantitative information. Admiral Dyer pointed out that "with the A-12, there was the perception that everything was fine one day and a disaster the next. Clearly, the right information was not getting to the right people."

Communication within and between product teams is key. Everyone mentioned the value of electronic mail as a communication medium. Captain Godwin, the current Program Manager, receives an average of 200 e-mails a day. The program office has developed a header format to indicate priority, an obvious necessity with that many messages.

Several people noted that team members are not punished for bringing bad news ("We don't shoot the messenger"). Several also made the point that people only get into trouble for holding back information.

Along with communication, there is a heavy reliance on detailed quantitative information. One of the interesting innovations on this program is the existence of a common, central database that is used by both the government and contractor to manage the program. This database contains hundreds of metrics, including financial data. In this way, both sides are working from the "same sheet of music."

Earned value has been used throughout the program as a management tool. According to Admiral Dyer,[13]

> Earned value has been the centerpiece of the way we've measured the program. At our Critical Design Review for the E/F, we had the

[13] Dyer and Conger "The Evolving Integrated Program Team."

> government and the industry IPT leader for each block in the work breakdown structure – air frame, landing gear, brake, brake subassembly – present their cost performance index, their schedule performance index, and their weight margin for the design. And early in the development we set up weekly reporting of these measures throughout the program. So I'm never more than a week away from knowing when I'm in trouble and where I'm in trouble.... It's very hard to find leading indicators in this business, but we found that granular earned value provides us, if not with a leading indicator, at least a cycle time to identify problems that we've never had before.

5.2 Team Leaders Are Key

Several people made the point that the team leaders are critical to the success of IPTs. They have to function as consensus builders but also be willing to make a decision when consensus cannot be reached within the team. They also have to be able to deal with a huge amount of information. Captain Wieringa, the E/F Level I Co-Leader, expressed it this way:

> We're asking the leaders at each level to have a lot of breadth. If you don't have the right people, you're going to have problems. With IPTs, we have much more data. We're weighing things that we never considered before because we have so much more information. This can be frustrating to people. IPTs give you knowledge so that each discipline understands what other disciplines really do. This is important because building aircraft is all about compromise.

In addition to being able to deal with multiple sources of information and multiple perspectives, IPT leaders have to be able to delegate. Rich Gilpin, the E/F Level II IPT Leader for Air Vehicle said "I may get up to 200 e-mails in a day. The sheer volume of work forces me to delegate responsibility to the Level III IPTs. Fortunately, I have very good Level III guys."

Rich Gilpin, pointed out that the F/A-18 program is fortunate in having access to exceptional talent: "The F/A-18 is a premier program. We get the best people. IPTs work great here."

5.3 Checks and Balances Provided by "Technical Conscience"

IPT members report to the IPT Leader. They also report to a supervisor within their own functional area (see Figure 2, Section 4.0). Not only does this matrix structure allow for flexible staffing of specific IPTs, it also allows each person to raise issues within his/her own functional area when necessary. This arrangement supports the concept of "technical

conscience" and forms the foundation for a system of checks and balances. Admiral Dyer said the following about technical conscience[14]:

> We were very careful to maintain a separate path for what we call 'technical conscience.' You cannot have IPT members who are oppressed by a strong team leader or who feel so heavily burdened by an integrated program that they swallow something that they just in their own conscience do not believe is right. So we've been careful to maintain a separate chain of technical conscience.

Captain Wieringa made a similar point:

> If an issue is a matter of technical conscience, one is required to raise the issue as high as necessary. We don't want group consensus overriding an important technical concern.

5.4 Strong Team Culture

During the interviews, numerous examples were cited of team collaboration. People are involved in working together to solve problems in ways that were not seen under the old way of doing business. Captain Wieringa cited an example in which the engineering solution to an uncommanded roll was suggested by the test pilot who originally reported the problem. "In the old days, the test pilot would characterize the problem and let the engineers worry about fixing it. Now there is a collaborative relationship and the pilots can suggest solutions."

The strong team culture extends to collaboration between government and contractors. This can, perhaps, be seen most clearly in the Integrated Test Team (ITT) that is carrying out the flight testing of the E/F model (Development Test and Evaluation). The ITT is a government-contractor team working together in testing, reporting, and analyzing anomalies and tracking status. As with all the F/A-18 IPTs, the test team members are from multi-disciplines and include engineers who were involved in the design of the aircraft and who are available to analyze problems discovered during flight test. The flight tests are performed both by the contractor and by Navy pilots; the results of the tests are shared across the entire team.

One of the advantages of this integrated government–contractor team approach has been much more cost-effective use of the test aircraft. Under the old way, there were periods during flight testing when the Navy ran its own tests. This was non-productive time for the contractor. According to Captain Bob Wirt, Government Flight Test Director, the contractor costs per aircraft are $50,000 per day. Thus, these non-productive periods were very costly. "Rather than specific dedicated Navy-only test periods, every day is a

[14] Dyer and Conger "The Evolving Integrated Program Team."

technical evaluation – productive for both the Navy and the contractor. Because this is a joint government–contractor team, the Navy is analyzing the results both as part of the test team and as a customer."

When asked whether there is any danger in too much collaboration between government and contractors, Captain Wirt replied,

> I'm the senior Navy official on the team who most directly represents the customer. It's important for me to keep that perspective. But I can tell you that the company test pilots are very demanding of their product and can be the most critical amongst all the pilots during their evaluations.

When asked how the F/A-18 program has managed to foster real teamwork between government and contractor personnel, Dyer responded as follows[15]:

> Leadership matters and personalities matter. Mike Sears, who was the Vice-president for F/A-18 at McDonnell–Douglas and I grew up together in the F/A-18 program, he on the contractor side and I on the Navy side. We had a trust and openness and a communication with one another that we knew we could build on. We knew that we could flow it down to others and that we would both insist on it.... Once we were sure we took care of technical conscience, we engendered, empowered, and insisted that we get communication between government and industry and, in those few cases where that didn't work, we rolled heads.

Admiral Dyer made it very clear during the interview that it is everybody's job to be a team player. As an example, he related the following scenario:

> We had a new government guy join us from another location. He stood up at a meeting and began by saying 'The contractor has failed to provide....' You could have heard a pin drop, the other members were so quiet. We realized that we hadn't heard that kind of language for a long time. And I told him 'What you just said is not acceptable. If the contractor hasn't provided something, it's your problem too. What are you doing about it?'

Admiral Dyer concluded the story by adding, "There really is a cultural change required. We're not taught to be team players."

5.5 Individuals Empowered (Given Resources, Authority and Accountability) Within Clearly Defined Roles and Responsibilities

It was noted in Section 3.0 (Historical Background) that, under the old way of doing business, disagreements between functional organizations were raised up the functional chain to be resolved at a high level. With IPTs, disagreements are resolved at the level at

[15] Dyer and Conger "The Evolving Integrated Program Team."

which they arise through empowerment of the IPT members (with the caveat that access up the chain is encouraged in matters of technical conscience).

IPT leaders have a lot of flexibility and autonomy to address issues as long as they operate within clearly defined boundaries. They are in charge of their own resources.

Rich Gilpin, the E/F Level II IPT Air Vehicle Leader expressed it this way:

> I can act a lot more autonomously now. I have much more freedom to do things as long as I operate within policy and procedures. I don't have to ask permission. I can just do it. But I do have to keep people informed about what I'm doing.... It's important to spend time at the beginning defining roles and responsibilities. You can't just assume that people automatically know.... I like this way better. I don't hear from the loggies anymore saying 'You dummy! Look at what you did to us.' As an example, recently we change the pylons to make them more stealthy. We installed a door to cover up the area. We left access holes so that the armament guys can see settings without having to open the door.

Admiral Dyer made the following point[16]:

> We used to have responsibility for the quality of the product distributed all over the command. Now we say 'Mr. Program Manager and Mr. Level I IPT Leader, you're responsible for the product.' That was the shift that made us. Because all of the sudden, people who used to be adversaries – T&E, logistics – became the folks who are going to save you and keep you from being embarrassed, who are going to keep you from building a product that doesn't work.

6.0 Example of an IPT in Action: Engine Stator Problem

Steve Bizzaro, the E/F Level II IPT Leader for Propulsion, relayed the following example of IPT members working together to solve a problem and implement a solution quickly. The E/F has two General Electric (GE) F414-GE-400 engines. On a Friday in November of 1996, during flight test, a stator or stationary airfoil, fractured. The debris from the stator caused significant damage to the downstream compressor stages, leading to a total failure in Stage 6 and a high-pressure stall. The test pilot landed safely and the problem was reported. The engine was shipped back to GE, and an investigation was begun to determine the cause of the fracture. Over the weekend, conference calls were held between the program office and GE, and on Sunday the decision was made to halt flight testing.

At this point, it was clear that the problem was related to high cycle fatigue but the exact cause was not known. The next step was to dismantle all existing engines in the remaining test aircraft. These engines were inspected in order to determine whether the problem appeared in multiple engines, indicating that the fracturing was a gradual process or whether the fracture was only in the one engine, suggesting that it was a result of a special combination of conditions that the test aircraft met during this one flight. The former was the case, that is, fracturing was found in more than one engine.

In Bizzaro's words,

> Under the old way of doing things, GE wouldn't communicate issues until they had a plan to go forward. They felt that problems and their solutions were entirely their responsibility. Now if there's an issue, we're the first to know. This actually works to GE's advantage because we have talented people here who can help. If there's a problem, we've probably seen it before. Under the old way, things wouldn't have been so open. GE was in favor of bringing in outside people. We brought in experts in high-cycle fatigue from the Air Force's Arnold Engineering Development Center, the Naval Research Laboratory, MIT, Purdue, and the Department of Energy.

Two weeks after the problem first surfaced, a meeting was held in which all data were discussed. Fifty different action items were identified relating to different tests that could be performed in order to identify the cause of the fracturing. One of the hypotheses was then verified through testing. The problem had been caused by a seemingly minor modification made to the stator for improved efficiency: the trailing edge of the stator vein had been restrained.

The solution was to return to an earlier engine configuration. Four engines were ready for the Initial Sea Trials in January 1997.

In just six weeks, we went full cycle from having the problem surface to diagnosing it and to installing new parts. We worked 24 hours a day, seven days a week, right through Christmas. All of us – the Propulsion IPT, the Integrated Test Team, McDonnell–Douglas, and GE – had a real sense of working as a team. Under the old way of doing things, this would have taken five or six months.

7.0 Lessons Learned

This section briefly describes the major lessons learned by those who had experienced the transition from a functionally aligned organization to a product-based one.

7.1 Expect that the Transition from Functional Stovepipes to a Product Orientation Will Be Difficult and Time Consuming

It was very clear from the interviews that the transition to IPTs did not happen overnight and it was not easy. There was a great deal of inertia to overcome. Some people resisted for reasons of conscience, feeling strongly that engineering concerns would not be adequately addressed. In other cases, the resistance appeared to be more of a reaction to a dramatic redistribution in power. The transition required persistence and courage on the part of the key people involved.

The transition can be very unpleasant. In an earlier quote, Captain Godwin, the current Program Manager described the transition as “gut-wrenching.” Admiral Dyer said, “If someone won’t play, they have to leave. You have to have people on board.”

In spite of the initial difficulty, there was a widely held opinion by those interviewed that IPTs work well in the F/A-18 program.

7.2 Pick the IPTs Leader Very Carefully

This point was made time and time again. The role of an IPT leader is not easy. IPT leaders are responsible for their products. They have to be able to process massive amounts of information and differing perspectives. They have to be able to delegate, to be consensus builders but actively seek dissenting opinions at the same time. They have to actively encourage early surfacing of problems. Clearly, this is not a job for everyone.

7.3 Clearly Define Roles and Responsibilities and Give People the Autonomy and Resources to Act Within Those Boundaries

The autonomy to act within clearly defined boundaries is an aspect of IPTs that appeared to lead to very high job satisfaction on the part of the IPT leaders who were interviewed. Admiral Dyer added that “Everyone loves the idea of empowerment but they have to remember that empowerment brings with it accountability and lots of sleepless nights.”

7.4 Implement a System of Checks and Balances

Within the F/A-18 program, the engineering organization is not as powerful as it was under the old system. Several engineers cautioned that there are real engineering concerns on any complex technical program and it is important to never lose sight of that. For the F/A-18 program, the concept of "technical conscience" is key. It is important to instill in people their responsibility to raise an issue as high as necessary if it is a matter of technical conscience. There are times when group consensus is not appropriate, or an IPT leader could make the wrong decision. There must be a mechanism to handle these situations.

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- Pam O'Dell (former P&SD Level I IPT Co-leader)
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- Jim Woolsey (former structures engineer within the F/A-18 program, a member of IDA’s Cost Analysis and Research Division)

9.0 List of Acronyms

CAO	Competency Aligned Organization
FMS	Foreign Military Sales
GE	General Electric
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
ITT	Integrated Test Team
MIT	Massachusetts Institute of Technology
NAVAIR	Naval Air Systems Command
OPNAV	Office of the Chief of Naval Operations
P&SD	Production and Systems Development
PEO(T)	Program Executive Officer for Tactical Aircraft Programs
PMA265	F/A-18 Program Team
POG	Program Operating Guide
RFP	Request for Proposal
T&E	test and evaluation

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13. SUPPLEMENTARY NOTES

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14. ABSTRACT

In 1994, the F/A-18 program was selected to be a prototype for implementing Integrated Product Teams (IPTs). This case study traces the evolution of the F/A-18 program from functional stovepipes to a product orientation in which all functional areas work together concurrently as a team. The case study was sponsored by the Office of the Under Secretary of Defense (Acquisition and Technology) to provide a real-life example of IPTs and Integrated Product and Process Development (IPPD) from an acquisition perspective. The transition to IPTs began with a high-level vision and required a great deal of thought, effort, and persistence to turn that vision into a concrete reality. Material for this case study came from a series of interviews that took place at the F/A-18 Program Office in Patuxent River, Maryland, during the Fall of 1997.

15. SUBJECT TERMS

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